BEBR

FACULTY WORKING
PAPER NO. 1029

Office-Function Productivity and Information Systems

Hirohide Hinomoto

College of Commerce and Business Administration
Bureau of Economic and Business Research
University of Illinois, Urbana-Champaign

BEBR

FACULTY WORKING PAPER NO. 1029

College of Commerce and Business Administration

University of Illinois at Urbana-Champaign

March 1984

Office-Function Productivity and Information Systems

Hirohide Hinomoto, Professor
Department of Business Administration

Office-Function Productivity and Information Systems

Abstract

Most information systems are implemented to enhance the efficiencies of office functions. They are usually selected through an economic feasibility study that analyzes their marginal costs and benefits. The marginal analysis satisfies the immediate need for selecting an information system to satisfy given requirements, but its Ptolemic view of the system fails to reveal its real economic impact of the system on the office function. Such an impact can be assessed by comparing the productivity of the function before the implementation of the system and that productivity after the implementation. Modified total factor or partial factor productivity ratios are proposed to measure the productivity of office functions when these functions perform activities essential to the operation of the firm. A case is discussed to illustrate the use of the proposed productivity ratios.

Office-Function Productivity and Information Systems

Introduction

Ever since the emergence of computers in the mid-50s, the productivity of the office has been continually enhanced by replacing manual operations with a computerized information system. This paper is concerned with proper measurement of impacts of such an information system on the office.

Productivity has been recognized as a major public policy issue in the United States since the middle of the 1970s when foreign producers succeeded in capturing significant segments of the American market for products such as steel and automobiles. The main focus of the issue, however, has been on the enhancement of blue-collar productivity, rather than white-collar productivity, through automation such as automatic process control in steel production or robots in automobile manufacture.

Generally, the main concern of an industrial firm is over blue-collar productivity, since the greatest part of its resources is committed to production. Economists are generally interested in blue-collar productivity, since the greatest segment of the resources of an industrial nation is tied up with industrial production. Reflecting these, most existing studies on productivity focus their attention on blue-collar productivity. Nevertheless, concepts underlying these studies are applicable to the measurement of white-collar productivity. Despite the fact that a growing number of information systems have been

implemented by business firms mostly to enhance office productivity, there is no commonly accepted method of measuring the impact of the information system on the efficiency of the office. This paper proposes a set of ratios useable for this measurement.

Information Systems

In their earlier applications, computers were merely regarded as fast calculating machines. Documents created by office personnel were converted to punched cards which were in turn fed into and batch processed by a computer. Although the earlier applications of computers to office activities caused great reductions in clerical force, they had relatively small impacts on the organizational formation. Starting around 1970, a growing number of firms have installed online terminals in their offices for direct data entry into or retrieval from the computer system, which has caused what may be considered the second wave of major reductions in clerical force at these firms. This time, not only has the online system caused a decrease in traditional clerical labor force, but ironically it has eliminated needs for keypunchers who were the product of the earlier computerization.

Whether data are entered into the computer from a device in the computer center or from a remote terminal in the office, assessing the costs of information systems supporting office sections is difficult because these sections usually share the same computer system in the computer center. However, from the beginning, labor cost savings have been identified as the primary objective of applying computers to office sections in most cases, although other reasons have been cited in minor cases [U.S. Bureau of Labor Statistics, 1960]. The emphasis on labor

cost savings was perhaps derived from the fact that these savings represented the greatest direct benefits available from the computerization in some cases, or they were the only measurable benefits in other cases.

Typically, the process of selecting an information system goes through a few steps. First, a few alternative systems are proposed for comparison from those systems that satisfy given information requirements. Second, each alternative system is evaluated for its marginal costs and benefits. Third, a particular system that offers the greatest net benefit is selected for implementation. However, this rational process is frequently modified by consideration given to intangible factors surrounding the information sytem.

The traditional, marginal cost/benefit analysis of an information system is a Ptolemic view of the system. It satisfies the immediate need for selecting a particular system. Since the ultimate objective of implementing an information system is to enhance office productivity in most cases, the real value of the system should be judged by its impact on the productivity of the office section for which it is implemented. The impact can be determined by comparing the productivity measures of the office section before and after the implementation of the system. Such productivity measures also enable management to compare the efficiency of an office section supported by an information system with the efficiency of the same section supported by another system or with the efficiency of a similar section of a competitor.

Productivity Measures

Economists have been using various indexes to measure the productivity of an industrial sector or an economy. Commonly used productivity measures at present are the total factor productivity (TFP) ratio (output per unit of all inputs) and partial factor productivity ratios (outputs per unit of major factors of input). TFP reveals the net savings in real factor costs per unit of output over time and thus the increase in productivity [Kendrick and Grossman, 1980]. TFP based on the gross revenue as output is limited in its usefulness at the level of the firm. Some researchers have recommended the use of the value-added productivity, TFP based on the value-added revenue; see, for example, Greenberg [1973]. Simply defined, the value-added revenue is the gross revenue from output (or shipments adjusted for inventory change) minus the cost of all materials and services acquired from outside. Greenberg [1973] points out that the value-added-per-manhour ratio would have as much variations among firms in an industry as five times in the average ratio between the highest 25 percent and the lowest 25 percent. This sensitivity is one of the reasons why the value-added TFP is considered more useful to business management than the gross-revenue TFP.

Partial factor productivity measures show the efficiencies of major cost factors such as labor, materials and contractual services, capital cost (interest, rents, royalties, and profit before taxes), and indirect business taxes [Kendrick and Creamer, 1961]. They reflect changes in input-mix resulting from factor substitutions, as well as technological advances and other forces impinging on production efficiency [Kendrick and Grossman, 1980]. One of the frequently used partial factor productivity measures is the labor productivity that

measures most commonly output per labor hour. Though this ratio is a fair approximation to a more comprehensive index of efficiency, it is usually subject to upward bias because of its failure to take into account not only capital but change in the composition or quality of labor [Fabricant, 1959; Denison, 1974; Kendrick and Grossman, 1980]. Kendrick and Grossman [1980] suggest using several variables to represent changes in labor quality affecting TFP, since, for example, changes in the age-sex composition of the employed labor force affect productivity because of the differences in average hourly earnings of various sex-age groups.

Denison [1974] emphasizes that "Advances in knowledge" relevant to production enhances the output obtained from a given quantity of resources, and is the most basic reason for the persistent long-term growth of output per unit of input. Although he refers to advances on technological and managerial knowledge in the context of production, similar advances are found in office environments mainly derived from advances in information processing technology.

Office-Function productivity

Generally, office activities can be divided into cohesive groups called office functions, such as accounting, finance, sales and marketing, purchasing, personnel administration, etc. The productivity of each such function, or the "function" productivity, may be given by the ratio of output per unit input of the function. However, office functions are generally known for the obstruse nature of their inputs and outputs. Inputs are less difficult to measure than outputs and normally consist of labor, capital facilities, information systems,

supplies, and others. If the function is staffed by personnel of equal skill, its inputs may be represented by manhours. Where different skills are involved, original manhours should be converted to those of a standard skill with proper weights assigned to the skills.

The costs of capitalized items must be converted to equivalent annual costs. Probably, the most important of such items in the office is the information system. If an information system is used at a constant rate over its life, its equivalent annual cost, E, is obtained as follows:

$$E = \alpha D \qquad \text{(dollars/year)} \qquad (1)$$

where D = initial development cost of the information system (dollars)

α = capital recovery factor

$= [i(1+i)^n/\{(1+i)^n-1\}]$

i = annual rate of return expected from capital projects (fraction)

n = expected life of the information system (years)

The main problem of determining office productivity is measuring outputs of the office. Frequently, an office function processes standard business documents; for example, the sales order-entry group might process standard order forms at an approximately constant rate; or the account receivable section might process invoices, spending about an equal amount of time per invoice. In these cases, outputs of the office function could be represented by the number of documents processed. Productivity measures based on such physical outputs are useful as long as the formats of documents do not change. In these cases, the productivity of the office function may be given by the following p or P:

$$p = \frac{N}{M} \qquad \text{(documents/manhour)} \qquad (2)$$

$$P = \frac{N}{C} \qquad \text{(documents/resource dollar)} \qquad (3)$$

N = the number of documents processed by the office function per day

M = the number of manhours worked by personnel of the office function per day

C = the total cost of resources used for the office function per day

The use of productivity measures in (2) and (3) is feasible as long as the same type of output is produced by the office function. Alternatively stated, their use is limited to a specific function of a particular firm for a relatively short period. What we need are productivity measures commonly useable by different firms without time restriction, like the total factor and partial factor productivity measures. Where an office function is essential to the operation of the firm, the ratio of the gross or value-added revenue per unit input represents a meaningful measure of the productivity of the function. Depending on whether inputs are measured in terms of manhours or resources expended for the function, this ratio is given by the following r or R:

$$r = \frac{V}{M} \qquad \text{(dollars of revenue/manhour)} \qquad (4)$$

$$R = \frac{V}{C} \qquad \text{(dollars of revenue/resource dollar)} \qquad (5)$$

where V = the gross or value-added revenue of the firm per day (dollars)

Since the productivity measures in (4) and (5) are independent of time, forms of physical outputs, and other special conditions of the

function or firm, they can be used for comparison of the efficiencies of similar functions of different firms.

This function productivity is explained in a matrix form in Figure 1 where rows represent factors of the office function and columns represent various office functions. The entries of the matrix are the annual costs of various factors of the function. The cross-functional sum of factor costs and the revenue of the firm are used to compute the partial-factor function productivity of the office as given in the right most column of Figure 1. The vertical sum of various factor costs of the office function is used to compute the total-factor function productivity of each function, as given in the bottom row of Figure 1.

In the short-run, the organizational structure stays fixed and, therefore, the costs of factors, such as labor and information systems, of each function do not vary too much. Consequently, great changes are not expected of all measures of office productivity. In a long run, however, a major change in organizational structure or allocation of factors within each function may take place, which may result in substantial changes in both the partial-factor function productivity and total-factor function productivity measures. Such major changes in organizations are invariably accompanied by implementation of new information systems.

Illustrative Case

The use of the productivity measures proposed above is illustrated through a case concerning the sales-order processing system at a large public utility. The utility used to have a manual order processing

system in which order-entry clerks received customer orders sent by telephone and wrote these orders on paper forms. These forms were accumulated during business hours; and their data were keypunched onto cards and summarily batch processed by a computer at the end of the day. In the middle of the 1970s, this system was replaced by a new system in which clerks entered sales-order data directly into the computer system through an online terminal.

The system conversion enabled the company to reduce the number of clerks staffing the sales order processing and related functions from 260 to 166, yet it increased the daily average of sales orders processed from about 6,500 to about 7,000. In Table 1 are given the annual operating costs and the types and numbers of personnel staffing the functions before and after the conversion. The old system's development cost had been fully written off before the system conversion. The total capitalized cost of the new system includes the equipment installation, remodeling of the office and computer center, and system development and implementation as listed in Table 2.

This utility used 8% as a discount rate for evaluating capital investment projects and 6 years as the expected life of the information system, which gives a capital recovery factor of 0.2163. Applying this value to the total capitalized cost of $1,996,000 has produced an equivalent annual cost of $431,735. The use of the equivalent annual cost is feasible, since the number of customer orders processed by the new system has not varied much from year to year since the system conversion. Since the format of each order has not been affected by the system conversion, the efficiencies of the function with the old and

new systems are determined by p and P in (2) and (3), using numbers of orders processed as outputs. Assuming 256 working days a year and using 6,500 and 7,000 as the average numbers of sales orders processed during a 8-hour day with the old and new systems, respectively, the function productivity with each system is computed as follows:

a. The function productivity with the manual-batch system

$$p_1 = \frac{6,500}{260 \times 8} = 3.12 \qquad \text{(sales orders/manhour)}$$

$$P_1 = \frac{6,500 \times 256}{4,404,898 \div 1,000} = 378 \quad \text{(sales orders/\$1000 of resources used)}$$

b. The function productivity with the online system

$$p_2 = \frac{7,000}{166 \times 8} = 5.27 \qquad \text{(sales orders/manhour)}$$

$$P_2 = \frac{7,000 \times 256}{(3,756,096 + 431,735) \div 1,000} = 428$$

(sales orders/$1000 of resources used)

With the productivity measures obtained above, the productivity improvement due to the system conversion is determined as follows:

$$\frac{p_2 - p_1}{p_1} = \frac{5.27 - 3.12}{3.12} = 69\%$$

$$\frac{P_2 - P_1}{P_1} = \frac{428 - 378}{378} = 13\%$$

The above result shows that the system conversion produced a significant increase of 69% in function productivity of labor, whereas it produced only a modest increase of 13% in total-factor function productivity.

Conclusion

Since their emergence in the mid-1950s, digital computers have been used to improve the productivity of the office. Traditionally, the feasibility of an information system is determined by a marginal cost-benefit analysis. Such analyses generally satisfy the immediate need for selecting a particular system in a given situation. Since an information system usually is implemented to enhance the efficiency of an office function, its real value to the firm should be determined by its impact on the productivity of the function.

Two types of ratios are proposed to measure the productivity of an office function, or the function productivity. The first type of ratios applies to special situations where phsyical outputs such as documents can be used to measure the productivity an office function. The second type provides more general measures of the productivity that are given by the ratios of revenue per unit of all inputs to the function. These ratios can be used to compare the efficiencies of the same office function with different information systems used in different years, or the efficiency of an office function of a company with the efficiencies of similar functions of other companies. The use of the proposed productivity measures is illustrated by a case representing a system conversion at a utility.

References

Denison, E. F., Accounting for United States Economic Growth, 1929-1969 (Brookings Institution, 1974).

Fabricant, S., Basic Facts on Productivity Change (National Bureau of Economic Research, 1959).

Greenberg, L., A Practical Guide to Productivity Measurement (Bureau of National Affairs, 1973).

Kendrick, J. W., Postwar Productivity Trends in the United States, 1948-1969 (National Bureau of Economic Research, 1973).

Kendrick, J. W. and D. Creamer, Measuring Company Productivity: Handbook with Case Studies (Conference Board, 1961).

Kendrick, J. W. and E. S. Grossman, Productivity in the United States (Johns Hopkins University Press, 1980).

U.S. Bureau of Labor Statistics, Adjustments to the Introduction of Office Automation, Bulletin No. 1276 (U.S. Government Printing Office, 1960).

Figure 1

Productivity of Office Functions

Factor of Office Operation	Factor Cost*				Partial Factor Productivity of the office**
	Function 1	Function 2	...	Function n	
Labor	a_1	a_2	...	a_n	$\frac{V}{\sum_i a_i}$
Capital Facilities	b_1	b_2	...	b_n	$\frac{V}{\sum_i b_i}$
Information Systems	c_1	c_2	...	c_n	$\frac{V}{\sum_i c_i}$
Supplies and Others	d_1	d_2	...	d_n	$\frac{V}{\sum_i d_i}$
Function Productivity**	$\frac{V}{a_1+b_1+c_1+d_1}$	$\frac{V}{a_2+b_2+c_2+d_2}$	...	$\frac{V}{a_n+b_n+c_n+d_n}$	Total Factor Productivity of the office: $\frac{V}{\sum_i (a_i+b_i+c_i+d_i)}$

*All costs are annual operating costs or annualized costs derived from capitalized initial costs.

**V is the annual gross or value-added revenue.

Table 1

Annual Operating Costs and Types and Numbers of Personnel
With Manual-Batch and Online Systems

Annual Cost	Manual-Batch System	Online System
1. Computer Equipment--Lease and Maintenance Costs and Sales and Property Taxes	$ 818,988	$1,440,888
2. Other Equipment--Lease Cost	108,050	47,050
3. Labor	3,415,560	2,248,858
4. Supplies	62,300	19,300
Total Annual Cost	$4,404,898	$3,756,096
Number of Personnel		
1. Office Clerks	245	166
2. Key Punching and Data Control	15	--
Total Number of Personnel	260	166

Table 2

Capitalized Costs of Online System

1.	Equipment Installation	$ 142,000
2.	Office and Computer Center Remodeling	639,000
3.	System Development and Implementation	1,215,000
	Total Capitalized Cost	$1,996,000
	Equivalent Annual Cost*	$ 431,735

*A capital recovery factor of 0.2163 for a life of 6 years with a discount rate of 8% has been assumed.